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TRANSACTIONS OF THE SOCIETY OF TROPICAL MEDICINE AND HYGIENE

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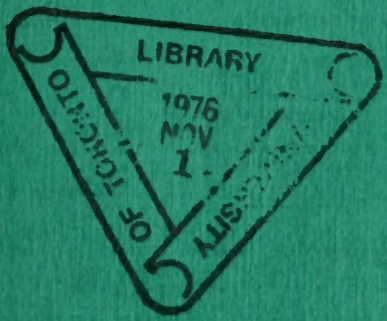

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TRANSACTIONS

OF THE

SOCIETY OF TROPICAL MEDICINE

AND HYGIENE.

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Proceedings of a Meeting of the Society, on Friday, May 27th, 1910.

PROFESSOR RONALD ROSS, C.B., F.R.S., *President*, in the Chair.

Professor RONALD ROSS, on opening the meeting, said he had been directed by the Council to write a letter of condolence to His Majesty King George V. on the death of King Edward VII., with an expression of loyalty to King George.

EMOTIONAL PSYCHOSES AMONG DARK-SKINNED RACES.

By DR. R. HOWARD, NYASALAND.

In any general description of the diseases encountered amongst tribes of negro origin, reference is often made to the occurrence of cases of bewitchment, or of supposed possession by evil spirits. The symptoms are frequently described in some detail, together with the treatment

which is traditionally employed or recommended by the local witch doctors. As a rule, however, the descriptions apply to a few striking cases, no general account of the emotional neuroses of the people being given; and it may be of interest to describe, and, as far as possible, to arrange systematically, all the cases of varying degrees of severity which have come under my notice.

The part of Africa with which I am personally acquainted is the country surrounding Lake Nyasa, especially the southern half of the lake, and my patients have been drawn mainly from the tribes living on its shores. The western shore of the lake is in British Nyasaland, while the eastern shore is partly in German and partly in Portuguese territory. The cases hereafter described have been drawn from all three districts, and their occurrence has extended over a period of eleven years. Although my experience is confined to a particular part of the African continent, I think that it is fairly typical, and that similar neuroses would be found, at least, among all the native races of Central Africa, although in matters of detail there would be special adaptation to local ideas and beliefs.

Any medical man who has worked among negroes must have realised the immense hold which their superstitions have on them. At the same time he will have found that it is very difficult to get them to talk about them. There is an atmosphere of terror which is too real to need description, and which it may be unlucky to discuss.

Moreover, the native knows that the European does not credit such beliefs, and so he is very shy of mentioning them. He may just throw out a hint that a man is

bewitched, or that such and such a disease is the result of magic, and then as soon as one attempts to cross-examine him he maintains an obstinate silence, and will say no more, for he feels that such questions are the heritage of the black man and not of the white, and had best remain so.

Hence it follows that, in many cases, one's information is fragmentary and the history imperfect. We cannot experience the all-pervading fear which is the most characteristic feature of the native's surroundings; but we must accept its existence as a fact, for it will help us to understand his neuroses.

The unseen world, so the native believes, is full of evil spirits with almost limitless power to harm him, and there are witches who can communicate with these spirits and use them against their enemies. Among the Nyasas it is firmly believed that a man can procure a charm which makes him invisible, and enables him, going about unseen, to lay traps for his neighbours; also that a man can turn himself into a lion or leopard at night and back into a man in the daytime. If a crocodile seizes anyone in the river, it is because it was brought there by magic and instructed to seize that person. Almost all diseases are ascribed to witchcraft, and the only way this can be met is by the use of countercharms, the very nature of which is generally unknown by the wearer—it is something that the old people in the village say will do good.

This all-pervading sub-conscious fear, coupled with boundless credulity and an undisciplined emotional temperament, will help to account for many of the special psychoses now to be considered.

I. Cases of Emotional Excitement.

Let us first take those of a violent nature, which are grouped under the native term "Misala," which in the dictionaries is translated "madness." In its simplest form this resembles an uncontrollable attack of temper. It occurs in excitable persons, and is often recurrent. The patient may appear cross and morose, and his companions tease him. He may tell them to leave off or he will get misala; but generally the teasing continues, and he seems to lose all control of himself, and rushes out into the forest so as to escape; or he may turn on his tormentors and throw stones at them; or, in some cases, he may throw himself into the water, but generally only when there are sufficient bystanders to ensure his being rescued. Sometimes he will go and set fire to a hut, possibly his own, in order to call attention to his grievances or to spite some one. The condition seems to be what, for want of a better word, we must call hysterical. It is very much increased by the stupid treatment which such patients receive from their friends. At first they look on and laugh, and often annoy and render the patient more and more self-conscious, and then when he gets up and runs after them, they are frightened and run away. All this helps to work him up into an excited state until he is hardly conscious of his actions, though he is generally careful not to hurt himself.

If the patient is brought to the European doctor at this stage he is excited and wild, with staring eyes, rapid breathing, and some tremor, but generally he can be controlled by a stronger will. If the aimless onlookers are sent away and the patient is told in an authoritative voice to sit down quietly he generally obeys. If asked

questions he may profess not to be able to answer them, and if he has done anything violent he often denies any knowledge of his act. The attack may pass off in an hour or so, and the patient can be given a sedative and sent away, more often he calms down, but when told to walk away does so in an excited, violent stamping manner, and has to be sent home under care, and he may be three or four days before he is all right. The patient who has once had this misala is liable to have it again. Most of the cases are in young adult males.

The native ideas of treatment are most inadequate. At first they make a great show of holding the patient and restraining his every movement, in spite of his protests that he wishes to be left alone. Later on, after a few hours, they tie arms and legs, or perhaps restrain him by putting him in a slave yoke. Can one be surprised that he struggles to free himself and rush out into the forest?

Even with this treatment, however, these mild cases of misala generally get better after a few days. A more marked case was that of a man aged about 30 (Mattiya Daniel), who came to me stating that he had at intervals during three or four months suffered from fits, which he boldly said were due to possession by a devil. There was marked increase of knee jerk and ankle clonus, and the tongue was tremulous. There was also considerable tachycardia and constipation, but nothing organically wrong could be found. The patient complained of the palpitation and constipation. He was admitted to hospital, and treated with carminatives and tonics. He had one fit when I was away, and two days later I was called to him, and he stated that he was about to have another. He was in a hysterical condition, laughing and crying and

rather twitchy. Pressure on the supra-orbital nerve soon brought him round. A day or two later the same symptoms were threatened while I was talking to him, but a firm command stopped them, and a few days afterwards he went home apparently much better. In another instance (Longa Longa, æt 35), a patient was admitted with necrosis of the lower end of the femur. He was most anxious to be operated on, but with the first whiff of chloroform he became stiff with a good deal of opisthotonus and apnœa, which lasted nearly a minute. Apparently there was loss of consciousness, but not of corneal reflex. Following the tonic spasm, there was a good deal of clonic convulsion. After a minute or two there was a second fit, with less tonic spasm and apnœa, followed by very rapid respiration. The operation was postponed, and the patient questioned. He admitted that he had been subject to fits of misala, which came on if he woke up suddenly at night. It was said to be very common in that part of the lake shore from which he came (German Nyasaland), and the remedy was said to be for the patient to rush out and spear a goat, and then drink the blood which flowed from the wound. Later on the operation was carried out. The same symptoms were repeated, but on pushing the anæsthetic they ceased, though a great deal of chloroform was required to keep him under. From indirect evidence it seemed probable that in his own home this patient was a witch doctor's medium or oracle, and that he was in the habit of working himself up into some sort of autohypnotic state in connection with this calling.

None of the above cases have proved very serious, but in one instance the complaint gradually developed until it culminated in homicidal mania.

When first observed in 1899 the patient (Julius Mluni) was a school-boy of eighteen years of age, characterised by a very undisciplined nature and a violent temper. When he was about twenty he had one or more fits of misala of the restless type lasting about a week, during which he ran out of the house at night and wandered about in the bush, so that his friends thought it necessary to tie him up. For the next few years he seemed well, but was an unsatisfactory character, often changing his work, quarrelling and at times drinking a good deal of native beer. When he was twenty-eight years of age the misala returned, and the patient seemed more violent during the attacks, though quite sane between times. Two years later he had two or three attacks in rapid succession, the last of which lasted about a week, and occurred while he was on the steamer on the way to his home.

On this occasion he was at times morose, and at times wildly excited, shouting and muttering, and then tried to throw himself into the lake, so that he required watching. Once, waiting his opportunity, he seized a hammer and hit a neighbour several violent blows on the head. A few days after reaching his home he was supposed to be well again, but suddenly he made an attack on his father with an axe, and killed him. He was a Portuguese subject and was placed under arrest in the government prison, but a month later I heard of him on his way to find work in the Transvaal, having apparently been liberated by the authorities as quite sane again !

This case seems to bear some resemblance to the " Amok " of the Malays. It is the only instance that I have met with where this misala, which for want of a better term one must perhaps call an emotional or

hysterical psychosis, has led on to serious acts of personal violence. To a certain extent this may be accounted for by the law-abiding traditions of the Nyasa race. Every injury to a neighbour is compensated by a payment, and even in their quarrels and fights the sub-conscious recollection that wounding your adversary means payment in goats afterwards, has a markedly restraining influence.

In obtaining histories and making enquiries about cases such as those above described, one is much hampered by the vagueness of native diagnosis which confuses together all instances of mental excitement. Thus, delirium during acute fevers, or convulsions during infancy, true dementia, post epileptic mania and epileptic idiocy, have all been described to me under the generic name of misala.

Epilepsy is certainly common among these people, and there are a fair number of epileptic idiots, though the latter often die young as the result of a burn or some other injury received during a fit. I have come across one case (Davies Mafani) of post epileptic mania. The patient had suffered when a boy of 18 from a condition diagnosed as status epilepticus. Later, at intervals of about a year, he had three or four attacks of petit mal, each of which was followed by transient mania. Since then he seems to have made a complete recovery.

Dementia is the most usual form of chronic insanity, and it is not very common.

II. Delusions of (a) Poisoning; (b) Bewitchment.

Another group of neuroses are characterised by depression, and are associated with ideas of poisoning or bewitchment.

(a) It is difficult to say how far criminal poisoning does go on in the country. It is only occasionally that

definite evidence can be obtained, and the crime brought home. I only remember one such case in my personal experience. Not infrequently there is very strong suspicion, and it is freely stated by the natives as a matter of certainty, but when it comes to the point, the relations of the deceased dare not give evidence against the poisoner for fear lest he should wreak vengeance on them. The poison used in Nyasaland for criminal purposes is said to be the partially decomposed bile of the crocodile, and it is usually given in beer.

In a very large number of instances, however, illnesses are popularly attributed to poisons where there is not the least shadow of evidence, or where there is definite pathological proof to the contrary. Still this widespread idea of the frequency of poisoning, coupled with the belief that poisons exist, which can produce almost any disease to which the natives are liable, is often responsible for a mental condition which militates greatly against recovery. The patient is possessed by the idea that he has been poisoned. He tries to meet this by taking emetics. If these fail to make him vomit, or if in spite of vomiting he is no better, it is not long before he is convinced that the poison is still at work, and that he cannot possibly recover. I have known this fixed delusion in a patient with severe Bilharzia disease, and also in one with chronic dysentery, and nothing that I could say availed to alter it.

In other cases the patients are perhaps ill with gastritis, due to over-indulgence in native beer. The resulting pain and discomfort is, however, attributed to poison, which, having been given them in their beer, has produced various irritating substances inside them.

I was called to one patient, a woman of about thirty (Florrie Chibwana), said to have been ill five days. She complained of "things" in her throat and stomach which moved about. She was constipated, but had a normal temperature; pulse 80; respiration 20. I gave her a purge and thought she would soon be better. Two days later I was told that she could not lie down, and was dying. I went and found her being held up in her mother's arms, surrounded by crowds of relatives who were awaiting her death. She was excited and frightened, and had taken no food for two days. Her tongue was clean, and she did not appear really ill. A blister was applied to the epigastrium, where she complained of pain, and the opinion that she would recover was expressed. Two days later she started vomiting (probably as a result of emetics administered by her friends), but was said to be better. I saw her five days later; she still had a normal temperature and a pulse of 80, and was taking food; but it was stated that she vomited twice a day, and that the vomit contained needles, charcoal, and india-rubber. These articles were still being produced in her, and she would not be better till she had got rid of them.

As I was incredulous, they promised to bring me up specimens from the vomit to prove their case, but needless to say they were not produced. This patient remained ill for three or four months, and did not really recover until she went to some relations at a distance. As far as I could judge, it was a case of flatulent dyspepsia with delusions of poisoning.

Another patient was a woman of about the same age whom I had long known as very hysterical. Her symptoms were very similar—a lump in the throat and abdominal pains and vomiting, which were attributed to

bones which had grown in her stomach as a result of poison. She declined my medicine, and after three months of unavailing treatment in her own home, she went to a distant medicine man of repute, who wet-cupped her over the sternum, and gave her the leg-bone of a chicken with about eighteen inches of string attached to it, which he said had come out in the blood clot! She returned triumphant, and showed it me, saying, "If you had had that in *your* stomach you would have been uncomfortable."

Another patient, a man of thirty-five, was in hospital with severe mucopurulent conjunctivitis. He got better and went home, but then had pains in the head. For these he went to a medicine man, and afterwards wrote the following report of his case: "A frog was removed from my head when I was cupped, a weevil came out of my eye, a live maggot from my stomach, and a coal from my bowel, and now I am a little better."

Ridiculous as such beliefs may appear to us, they are very real to our native patients. If we laugh at them they simply put it down to the white man's prejudice and ignorance of the real cause of the illness. The only way to cure them is to gain their confidence, to assure them that they will probably recover, and then treat them on ordinary lines for indigestion. Doubtless, the native medicine man's conjuring tricks may at times be very effective, but to copy them would not be legitimate medical treatment.

(b) In another group of cases, witchcraft and not poison constitutes the subject of the obsession. Here, too, there may be some obvious pathological cause for the illness, but it is attributed to witchcraft. I had one patient, a woman of about twenty-two (Nia), brought to

hospital by my native dispenser, with the statement that he had found her in a hut, surrounded by relatives who were awaiting her death. It was with much difficulty that they were persuaded to let her come to the hospital, and only on condition that her mother accompanied her, as she was expected to die on the way. They did not know what was the matter with her, but she had been ill three months and got no better, so they thought she was bewitched. She was an obvious case of ankylostomiasis, with marked anæmia, and loud hæmic murmurs and shortness of breath. She responded readily to treatment with eucalyptol and iron, and went home well in less than three weeks. Another patient was suffering from rather severe Bilharzia disease, which is extremely common on Lake Nyasa, but he was convinced that his illness was due to his wife having cursed him in his house, and nothing could persuade him that his was the ordinary and well-recognised complaint.

The most striking instance that I have come across was that of a youth of about twenty-one (Basil Zimchaya), who was studying at the training college for teachers. In November, 1902, he was seized with palpitation of the heart, and was thought to be dying. This attack passed off, but he remained ill and still complained of cardiac pain, so in December his relations, who were convinced that he was bewitched, took him home. He was removed at night in the hope that the man who had cast the spell over him would not know where he was, and so it would be broken. This did not seem to answer, however, and he became steadily worse, in spite of a whole collection of charms with which they adorned his person. Two months later, in February, 1903, he was brought to my hospital. He looked the

picture of misery—thin, frightened, tremulous, scarcely able to walk, and quite convinced that he was going to die. His temperature was normal, respiration 20, pulse 136 and irregular. Heart dilated, impulse diffuse in sixth space and outside the nipple line, and there was a loud systolic murmur. Knee jerks were greatly exaggerated, and there was ankle clonus. The spleen was one and a half inches below the ribs. Examination of the stools showed a very small infection with ankylostomes, only an occasional ovum being seen in the fæces. The patient was admitted to hospital, and was no longer worried by his relations, and he was assured that he might recover. He slowly improved, but the heart continued rapid and irregular. A course of thymol was given for the ankylostomiasis. The patient was also found to have membranous colitis, and large casts of the bowel were passed. By April no cardiac murmur was audible, and the impulse was inside the nipple line, and the pulse was more regular. In July the pulse was normal, and the patient returned home. He was still a nervous, excitable subject, but he no longer thought he was bewitched. A year later he returned, saying that his heart was bad again, and it was found that the cardiac murmur had reappeared, and that he had organic mitral disease, with its usual attendant symptoms. Since then, up till 1909, he has been under observation from time to time. He has fairly well compensated mitral disease, with a loud but variable systolic and sometimes a diastolic murmur, and a hypertrophied heart. He is, however, now convinced that all his troubles are due to his heart, and so long as he does not overexert himself, he is able to live an ordinary life and work as a native teacher. I have often told him that no further improve-

ment is probable, but he has been cured of the delusion of bewitchment, and he has the most profound belief in me as a doctor, and considers that I "really understand his constitution." Here, then, was a case where incipient heart disease had been attributed to bewitchment, with very nearly fatal consequences to the patient.

In other instances there seems to be little or nothing organically wrong, and the obsession of bewitchment, which often originates, in the prophecy by an enemy of death before a certain date, constitutes the whole disease. The patient may complain of a lump in the throat, but the most prominent symptom is palpitation with marked tachycardia. There is a frightened look on the patient's face resembling at first sight that of Graves' disease, but apart from tachycardia and perhaps exaggerated knee jerks no other abnormal signs can be found. There is no dilatation or hypertrophy of the heart, and on auscultation the cardiac sounds are normal, and the pulse though rapid is full and regular. Some six cases of this kind have been observed. It is no uncommon thing to find a pulse of 130-140, and, allowing for some increase as the result of the excitement caused by examination, this degree of tachycardia is striking. In one patient the pulse was 156 when first seen, and ten days or so later it was still 132.

If these cases come under treatment in a regular hospital they generally recover; left to themselves in the village some gradually get better, perhaps as the result of some charm or medicine which they have found, or perhaps owing to the departure of the person who has cast the spell, or to the removal of his supposed motive by some reconciliation. In other cases the obsession gets more and more pronounced, and it is fostered by anxious

relatives, who tell the patient that he cannot possibly recover. He gradually passes into a condition of what might be called Anorexia Nervosa. He is convinced that food will do him no good, and so refuses it altogether, and rapidly wastes and then dies. In the case of children, the mother or some other relative may facilitate the final issue by holding a hand over the face, with the idea that as the child is going to die, it is no good fighting against the inevitable, and the kindest thing is to help it to die quickly.

III. Auto-suggestion and Death.

While on this subject mention must be made of the extraordinary power which negroes seem to possess of giving up hope and lying down and dying. I think that it must have been noticed by all practitioners in Tropical Africa. The actual determining cause of death generally seems to be exhaustion from lack of nourishment, for it is far from uncommon to visit a patient in his own home and on enquiring about his diet to be told that he has taken nothing but water for five days or more. If you ask why, you are told because he does not want it, and no one tries to coax him to take anything.

As an instance I may quote one patient of about forty-five, whom I had in hospital with ankylostomiasis. He had been ill over a year, and had had a large number of native remedies, and was discouraged about himself when he came to me. He had a severe infection, and was decidedly anæmic, but had no specially bad symptom. He was very constipated, so was given a preliminary dose of castor oil, which caused three actions of the bowels.

After that he absolutely refused to take any more medicine, saying that mine had not cured him, and nothing would do so. Then he declined food, but would take milk. Next day he would take nothing. He was tired of life and wished to die. Nothing was of any avail, though he was quite willing to sit and argue the matter, and detail his symptoms, and all I could do was to send him back home, where, doubtless, he carried out his intention.

I have endeavoured, though I fear very inadequately, to describe and classify the psychoses and obsessions which have come under my own observation in Central Africa, and I hope that I have touched on a subject that is not without interest and importance. Every doctor who deals with native patients in a tropical country will find that he is constantly being brought in contact with the same or similar phenomena, and that they influence most powerfully their progress towards recovery, or retrogression. The more attention that is paid to them, the wider and more far-reaching their influence appears to be. They cannot be ignored or dismissed with a smile of contemptuous superiority, but need to be realised, and allowances must be made for them in the conduct and treatment of cases.

In conclusion, may I venture to express the hope that some of those here present will out of their great store of experience supplement my remarks, and elucidate the subject during the discussion.

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DISCUSSION.

Dr. COOK said he had listened to Dr. HOWARD'S paper with great interest, partly on account of the intrinsic difficulty of the subject, and partly because the lecturer's experience in Nyasaland so closely tallied with his own work in Uganda. It was a subject which involved much study because it was not easy to get the "hang" (if he might use the term) of the native's mind. In his opinion, all nervous diseases were subjects of very great difficulty, but they were doubly so when one had to deal with native races, whose customs were extremely difficult to understand and whose vocabulary in all abstract ideas was so limited. But there was one point to which he would like to draw attention as perhaps forming a subject to be discussed by others, viz., that very often where a neurosis was regarded as purely functional there was a true organic basis to it. He had noticed several instances mentioned in the paper that must have struck other members present in the same way, so that perhaps they need not be alluded to in detail; but there were a few which he might quote from his own experience. For example, a case to which his attention was very forcibly drawn was that of a woman who was brought to him by her friends, who said that she had gone out of

her mind, would not touch food, remained speechless, and preferred to live in the jungle. She had the typical aspect of pure hysterical aphonia. On pressure upon the supraorbital nerve she at once began to pay more attention to what was said to her, and when the battery was applied she became quite voluble. But on testing the glands in the neck many trypanosomes were found. In passing, he would also like to draw attention to the fact that in cases of tick fever in Uganda hallucinations had been noticed to occur with that disease, and he thought it was a useful point of enquiry because it was one where help could be obtained from Europeans who, like the natives, got tick fever, but who were able to give better descriptions of the symptoms than the natives. One had frequently found that there were hallucinations of some beautiful vision of fairies and the like. He thought a certain number of these cases were due to the administration of an hypnotic, like morphia, etc.; but he was quite sure that in some cases it was also associated with the invasion of the spirillum. Maniacal outbreaks had also been associated with the presence of helminthiasis. One must acknowledge that in spite of many cases of misala, excitement being traceable to an organic cause, there remained a number of cases where the cause had not been ascertained; but one should not assume that they were purely hysterical until one had found oneself in a position to definitely state that no organic cause could possibly account for it. The generally stolid character of the natives was the reverse of an hysterical temperament. In most cases one needed pretty strong evidence that there was no organic explanation of that functional disturbance. Of course, there were certain patients who exhibited very highly strung nervous

dispositions, and just as in England one so often found a voluble patient who would take a quarter of an hour to describe his ailment, so in Africa one sometimes came across patients who described an ailment like wheels revolving in their interior and travelling over their whole bodies, and the graphic description would be continued for many a long half-hour! With regard to the question of suicidal mania, he thought different races exhibited different tendencies to that ailment. He remembered seeing many cases amongst the Bahuma tribe in his neighbourhood who had committed suicide because they had suffered loss of cattle. He had also had to treat many cases in which pain, pure and simple, had led to attempted suicide. With regard to auto-suggestion and death, there were a certain number of natives who made up their minds to die, and die they would—that was, if they were allowed to do so. He believed it was possible, in a great many cases, to prevent this sad result by forced feeding, and thought Dr. HOWARD had given a valuable hint in saying it was due to lack of nourishment. He (Dr. COOK) had administered food to such patients by a catheter passed through the nose, and the patients had put on flesh and had steadily begun to recover.

NOTES ON INFECTIONS WITH SCHISTOSOMUM JAPONICUM.

By Dr. HENRY S. HOUGHTON,

Wuhu General Hospital.

It has become increasingly evident in the past year or two that the distribution of this trematode is wide-spread in central China, and that it is of more importance than formerly was thought. To the present time its presence has been reported in China, from Hunan, Honan, Hupeh, Kiangsi and Anhui provinces; outside of China it has been found in Japan (whence it was first described in 1904 by Katsurada), in Singapore (Catto), and in the Philippine Islands (Woolley, *Philippine Journal of Sciences, '06*).

It has been under the stimulus of the Research Committee of the China Medical Association that the wide-spread areas of infection in China have been recently brought to light, and in the work of the Committee that the series of forty cases here analysed was observed. The following notes deal with the clinical manifestations of the infection only; no necropsies have as yet been obtainable, but it is hoped that in the near future further pathological studies may be made.

In this institution, eight per cent. of all male cases entering during the past year showed infection, latent, active or overwhelming.

Age.—The youngest case observed has been fifteen years of age, but patients occasionally say that they have been infected from the age of seven or eight. The value of this sort of history is, I think questionable, but it should be kept in mind until more is known of the

mechanism of infection. The oldest patient in the series was fifty-four years old, and dated his first symptoms back seven years.

Sex.—Only males have been found infected thus far, but no systematic study has been made among women.

Locality.—Patients have presented themselves from places all through the southern half of the province of Anhui, roughly a circle with a diameter of a hundred miles of which Wuhu is the centre. It is to be noted that the distribution of the parasite in China follows in general the flat low-lying lands of the central valley of the Yangtse and the valleys of tributary waters; in Anhui, at least, its presence is limited to the rice-growing divisions of the country. No cases from hill or mountain country have appeared. PEAKE, however *(China Medical Journal, '08)*, reports that it is common among raftsmen in Hunan.

While occasional cases come from villages scattered throughout the area above mentioned, there are at least two foci where the infection is exceedingly common. Those who come from near these places have all agreed in saying that one in every three or four (some say even more) of the farmers and boatmen there are infected; that is, that they show the gross physical signs of infection, chronic dysentery, ascites, splenomegaly, etc.

Occupation. — Farmers and boatmen are peculiarly liable to invasion by the worm. Of our series all but one had worked on a farm or at boating during some period of their lives. Several cases have been among servants who have not been in the country for many years. One history is rather suggestive in this matter—that of a youth who had been in the constant employ of foreigners for more than three years, and so presumably not exposed

to infection. Before that time he had been farming in Kiangsi. Another interesting, but perhaps less reliable, history is that of a man, aged thirty-four years, who said that he first had a chronic dysentery at thirteen years of age, which had recurred from time to time until the present. He came from Tung Chen originally—one of the two important foci above mentioned—and had been on the farm and a boatman until he was sixteen; since that time (eighteen years) he had been a servant in an official yamen, and, later, a petty shop-keeper, always in the city of Wuhu.

The one exception in the series was a case who stoutly denied that he had ever lived on a farm, or that he had ever been in any way intimate with water; but said that he had been a soldier and personal servant in an official household since his youth, and had spent his childhood in a city in Shantong. He had spent eight years in Wuhu, and his symptoms were recent, dating back three years.

Symptoms and Physical Findings.—Clinically the cases may be classified as follows:—

(a) Typical cases showing enlarged liver and spleen, hydroperitoneum, and bloody stools. (Sixteen cases.) These are called "typical," not so much because they preponderate, as because they determine what is usually the final picture, and because the facies is so characteristic.

(b) Cases showing only splenic enlargement—with or without blood in the stools. (Eleven cases.) These, more especially the cases which show no blood in the motions, are likely to be a source of error in diagnosis. From the history, the appearance of the patient, and occasionally after an examination of the fæces, one may believe that he is

dealing with a malarial cachectic, or with kala azar or some similar condition. There are times when the ova either are absent for a while, or are exceedingly sparse, and their presence is not infrequently overlooked. Only a careful examination of the blood will throw light on such a case, and the fæces may be re-examined, or washed and sedimented, for confirmation. Eosinophilia of over 10 per cent. has here been seen only in connection with Schistosomum infections. The average number of eosinophile cells in the differential count is 25 per cent.: the highest has been 51 per cent.

(c) Cases with cerebral symptoms and a high grade of eosinophilia. (One case.)—One patient presented a partial hemiplegia of the left side—upper segment—and slight disturbances of speech, which had appeared in the course of a high fever three months previously, and which was thought to be malaria. He had been passing slight amounts of blood for three years, but said that it was from a fissure in ano; on examination he was found to have a small teat-like pile externally, which showed, however, no abrasions nor signs of recent bleeding. The rectum was clear. His stools showed a streaking of fresh blood. There was an eosinophilia of 47·4 per cent.; but physical examination was otherwise entirely negative.

There is nothing, obviously, to prove the connection of the cerebral lesion with the flukes, but in view of the marked blood reaction, and the fact that brain involvement has been recorded (TSUNODA, etc.), the case was thought sufficiently suggestive to record here. It is conceivable that malaria or typhoid with

a high pyrexia might stimulate the passing of great numbers of ova into the blood stream, to be swept outward and lodged as emboli elsewhere.

(d) Cases negative, except for marked eosinophilia. (Ten cases.)—A number of patients have come for the treatment of varying conditions, and the existence of the trematode infection has been discovered only incidentally in an examination of the fæces or of the blood. That a concurrent infection with the parasite is an important factor in these cases, especially surgical ones, is not to be doubted; it is unfavourable both from the theoretical and practical point of view. The relative great increase of eosinophile cells is at the expense of the polynuclear neutrophiles, presumably diminishing the power of this bodily defence against bacterial invasion; and as a matter of fact these patients as a rule do very badly under surgical procedures.

(e) Latent cases, showing ova in the stools, but no bodily reaction. Two cases in the series showed no reaction to the parasite. One gave, however, a history of recurrent dysenteric seizures.

Summary of Clinical Considerations.—The most important points clinically are:—

(1) *The presence of ova in the stools.*—This is not always easy to show.

(2) *A high grade of eosinophilia*, ranging from 10-50 per cent.

(3) *Greatly exaggerated knee-jerks*, which occur in practically every case.

(4) *Lack of anæmia.*—The average hemoglobin index in our series was over 80 per cent., but there is a peculiar muddiness of complexion that often suggests anæmia.

(5) *Lack of leucocytosis.*—Unless complicated by some purulent process, the leucocytes remain at or below normal. The counts, in uncomplicated cases, have ranged from 2,000 to 8,500.

(6) *Emaciation*, not to be accounted for in other ways, is occasionally a feature.

Ova, miracidium, etc.—Ova of Schistosomum japonicum have been sufficiently described to call for no further description here. The size is subject to rather wide limits of variation; some are practically the size of Ascaris l. ova, some have been seen (in older specimens of fæces) in which the usual rupture of the shell by longitudinal dehiscence did not take place, but the shell gradually enlarged, and the miracidium emerged through a pore. This is very unusual, but when observed is likely to be very confusing—the shell in such cases may be very large, relatively.

I agree with LOGAN that the ova of Sch. j. may be much more readily mistaken for Ascaris l., than for Ankylostomum eggs, or any other. When the mammillary envelope of Ascaris eggs is not deeply bile-stained, and the bosses not prominent, the two may be difficult to distinguish. The novice would be likely to take a Schistosome ovum for such an Ascaris egg, and neglect to turn on the high power. Schistosomum ova are, however, very refractile, which Ascaris are not, and this is often a help; they are also rather sticky, and gather débris, which may partially obscure the outline. It has been interesting to note that ova in blood have frequently the roughness of burrs, owing to the accretions of leucocytes on the surface.

One observation has been made, which is mentioned without comment or deduction. A preparation was made

from a stool containing practically pure blood, the film containing one ovum very near the edge of the cover-slip. As the room temperature was unusually low, the slide was placed in the thermostat, in the hope that hatching might be facilitated. On examination two or three hours later, the ovum was noted to have moved for a considerable distance, the path taken through the evenly spread corpuscles being very noticeable. As there was but one ovum in the specimen, it is difficult to see what might have occurred other than independent motion. I have not seen note of such a phenomenon. The observation above recorded was corroborated by Capt. HUFF, U.S.N. No further motion could be elicited.

The free-swimming miracidium in freshly passed stools has not been seen here; none have hatched under ten hours from the time of passing. In a perfectly fresh specimen the embryo is quiescent; the first motion to appear is usually a circumscribed ciliary or circulatory movement in two small areas, anterior and posterior. The current is always in the same directions.

The next appearance of life is in the cilia that cover the body, and, finally, general bodily movements begin.

When hatched, the miracidium moves about with the utmost freedom and activity, assuming any shape convenient to its progress. The only variation noted in miracidia here was one in which the papilla was distinctly trifid. Attempts made to keep the miracidia alive over long periods of time have all failed; whether the failure is due to faulty technique or to low viability of the organism one cannot say. Five days is the longest period in which free miracidia have been kept in fresh water, daily changed.

Discussion.

Dr. Sandwith said that when one remembered that it was only six years since this worm had been independently described by Katsurada and Catto, it was interesting to note that the China Medical Association had already collected forty cases of human infection. The symptoms mentioned included chronic dysentery, ascites, splenomegaly, and slight anæmia, and had the writer of the paper been present he would like to have asked him whether it was not possible that these symptoms could be confused with the condition known as Banti's disease? Another question he would liked to have asked was how could anyone account for a disease (which apparently only attacked the digestive system) presenting "greatly exaggerated knee jerks?" Was it not possible that there might be some infection besides the parasite? He thought it would be a convenient occasion to read a few paragraphs from a private letter written to him last February by Dr. Ernest C. Peake, of Heng-Chow, who had also sent a piece of liver showing the eggs of Schistosomum Japonicum. Dr. Peake writes:—"I have little to add to my former description of the symptoms caused by Schistosomum Japonicum, as published in the Journal of Tropical Medicine, March, 1909. I then pointed out that the symptoms presented by patients suffering from this disease are largely those of portal obstruction. We have all the backward-pressure symptoms, consequent on obstruction of the portal circulation, with chronic venous congestion of spleen, stomach and intestines. Thus we find enlargement, and may be tenderness, of the liver and spleen, chronic gastric catarrh and dyspeptic symptoms, irregular diarrhœa, ascites, general malnutrition and weakness. Blood and mucus

are not infrequently found in the stools. In advanced cases we may have extreme emaciation and weakness, with shrinkage of the liver, owing to the marked degree of cirrhosis which has taken place. In addition to the above, possibly due to some toxin generated by the parasite and absorbed into the system, we have fever. I found the temperature usually sub-normal during the day, but rising to 101° F. or more during the night. Examination of the blood shows a marked eosinophilia.

"*Pathology.*—From a consideration of the symptoms, I thought it not unlikely that the parasite might take up its permanent lodgment in the smaller branches of the portal vein, and that its irritating presence there would cause a peri-vascular cirrhosis, with compression of the vessels, consequent blood stasis, and backward-pressure phenomena in the abdomen. Only post-mortem examination could clear up the immediate cause of the portal obstruction. I think I mentioned to you before that Dr. THOMSON of Hanchow, had had the opportunity of making a post-mortem examination on a case which had died from Schistosomum Japonicum infection in his hospital. It was from him that I obtained the bit of liver substance that I am sending you with this. Dr. THOMSON showed me some sections that he had cut and stained from the liver. The tissue was simply crowded with ova. The white areas, visible to the naked eye, consist of fibrous tissue. What were apparently portal vein terminals were seen to be plugged with ova, and surrounded by fibrous tissue. Nowhere in his sections did he come across an adult worm. I had supposed that the parasite itself caused cirrhotic changes in the liver; but apparently the pathological condition of this organ is due, not so much to the presence of the parasite, as to

the blockage caused in the venous terminals, etc., by the crowds of ova. Perhaps the adult worms are situated in the small radicals of the portal vein in the intestines, and elsewhere, and the ova, carried by the blood stream, are caught in the venous meshwork of the liver. Dr. THOMSON wrote me saying he was unable to find ulceration of the mucous membrane of the colon (as described by CATTO), but instead he found everywhere 'warty-like excrescences rather hard and fibrous to the touch. Sections of the bowel showed ova teeming in the mucous coat forming the warty growths.' This I suppose would account for the occurrence of ova in the stools. Dr. THOMSON also found the peritoneal glands packed full of eggs. He says, 'Altogether in the liver, glands, and intestines there must have been countless millions of ova.'

"I have written to Dr. THOMSON, urging him to publish the results of his findings, and I am quite hopeful that he will do so.

"Meanwhile I send this bit of liver from his case, and hope you may be able to get some good sections from it which will show the ova plugging the small vessels, with fibrous tissue round about. If you get good sections they might prove interesting to other Fellows of the Society of Tropical Medicine and Hygiene."

The sections now under the microscope could be compared with cirrhosis of liver caused by Schistosomum hæmatobium, and some Fellows may remember that he showed some specimens of eggs of these in November, 1908. He thought it well to get an expert's opinion on the pathological lesion, and therefore submitted the sections from China to Professor S. G. SHATTOCK, who had obligingly sent him the following note:—

"The microscopic sections show foci of small celled

infiltration in the interlobular connective tissue formed around small groups of the ova of the parasite. In many cases the ova are dead, and their chitinous capsulę collapsed. The proper hepatic tissue is uninvolved. In the case of the larger portal canals the infiltration is more diffuse, but here the same minute knots of more acute formation occur, the centre of each of which is constituted by a group of ova."

THE BIONOMICS OF HELMINTHS.

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My purpose in this paper is to lay before you some general considerations on the subject of helminth parasites. These will be derived from a study of the subject, not so much as it affects man, but in its wider relation to other vertebrates, and an attempt will be made to interpret in terms of general principles the facts which we know concerning human helminths. The treatment will be almost exclusively biological.

One of the first outstanding principles in helminthology is the fact that, with comparatively few exceptions, the definitive or final host is a vertebrate. The exceptions are to be found amongst certain insects and myriapods which harbour adult nematodes, but no case is known of an invertebrate serving as the final host of a cestode or trematode. On the other hand, vertebrates and invertebrates alike may function as intermediate hosts. Generally speaking, therefore, invertebrates are parasitized only by larval stages, while vertebrates are subject to both larval and adult stages.

A second important fact is that helminth parasites can have no existence apart from their hosts, by which I mean that their life is indissolubly bound up in and dependent on the latter. It is true that they may survive the death of their host for a longer or shorter period, and may even make their exit from the dead host and be found at some distance from it, but their life is practically at an end, and they can never hope to make any prolonged existence thereafter. On this account it

has been found impossible to keep adult helminths alive under artificial conditions for any length of time, although theoretically if the exact physiological conditions of the habitat could be reproduced, it is not altogether an impossibility. Various larval stages have been reared in artificial media, but never beyond the point at which a living host was necessary for their continued development. In the case of intermediate stages the death of the host does not necessarily imply the death of the parasite, provided the former be eaten by some animal suitable as a final host. In such a case the parasite is enabled to complete its life cycle; otherwise it must inevitably perish. The rare cases of heterogenesis are no exception to this, for even although in such cases a sexual cycle is passed through outside the host, the helminth eventually requires a host, and if that be withheld its life will be cut short.

Present knowledge seems to point to the fact that practically no species of animal can be considered immune to infection with helminths of one kind or another. The degree of susceptibility varies to a great extent in relation with the general habits, the mode of feeding and certain imperfectly known physiological idiosyncrasies. The susceptibility to the various kinds of helminths also varies in a similar way; thus the dog is particularly prone to infection with cestodes, but rarely harbours trematodes. Certain species of helminths are capable of infecting a large number of different hosts, whereas others are confined to one particular host, *e.g.*, *Tænia solium* occurs only in man, while *Fasciola hepatica* occurs in a variety of mammals. Again, some hosts harbour numerous species of helminths, even as many as ten or a dozen different species being present at the same time, while others may

harbour only one species, although that may occur with great frequency and in excessive numbers.

From a medical point of view only such helminths are of interest as a rule, as call for medical treatment, and in consequence a somewhat inaccurate idea is apt to be engendered of the true importance of helminths in general. There is a tendency to forget that cases giving rise to symptoms form only a very small proportion of the total number actually infected. It has long been recognized that the occurrence of helminth parasites is very widespread. In 1845 DUJARDIN recorded that he found helminths in 53 per cent. of the 2,400 animals which he dissected, and of these, for the most part, only the alimentary canal was examined. Since that time various isolated statistics are to hand of the frequency of helminth infection amongst the different groups of animals. These are chiefly from continental abattoirs and are concerned with the domesticated animals. They show, however, that even in the domestic state where a certain amount of care is exercised in the feeding arrangements, infection reaches a very high degree. At Copenhagen, for instance, KRABBE found 86 per cent. of the horses infected with *Strongylus equinus* alone, and practically 100 per cent. harboured helminths of some kind or other. He also found that 67 per cent. of dogs had intestinal parasites. This figure would undoubtedly have been much larger had the other viscera been examined in addition. CURTICE, in 1887, found 87 per cent. of sheep in Colorado infected with the tapeworm, *Moniezia expansa*. HERTWIG, in 1890, at the Berlin abattoir, examined 150,000 adult bovines, and met with *Fasciola hepatica* in 75-80 per cent. These figures form rather a disagreeable commentary on the cleanliness with

which our domestic animals are housed and fed. In birds HAUSMANN has recorded an infection, with trematodes alone, of 30 per cent., and WOLFFHÜGEL 21 per cent. These were mostly inland birds, but in aquatic birds the percentage is much higher. On the east coast of Britain, for instance, I have found infection in over 90 per cent. In reptiles and amphibians I have no figures at hand, but here also infection is very high. Finally, in fishes I have found a constant infection of over 80 per cent. in the British fishes. In view of these figures, then, it cannot be regarded as an excessive estimate that 75 per cent. of all vertebrate animals are infected with helminth parasites of some kind or other. This may serve to indicate in a crude way the extent to which helminth parasitism enters into the economy of nature.

Such being the case, we can hardly fail to come to the conclusion that the presence of helminth parasites in vertebrate animals must be regarded not as an abnormality, but as a normal condition just in the same way as the presence of intestinal bacteria may be considered normal. The belief has more than once been advanced that helminths may even exercise a beneficial influence on their host. To some this idea may appear quite in discord with the medical conception of parasite as something loathsome and highly dangerous. The belief is founded on the fact that most helminths secrete a more or less irritating substance which may have the effect of stimulating digestion. There is, however, no direct evidence of this, but it is now generally agreed that the influence of helminths for the most part is, if not beneficial, at least comparatively innocuous. It is only when some vital organ is invaded, or when infection reaches an excessively high degree that harm results. In the latter

case, however, it is difficult to know where to fix the limit. For instance, DUJARDIN quotes two cases, in one of which a black stork harboured 24 specimens of *Filaria labiata* in the lungs, 16 *Syngamus trachealis* in the trachea, more than 100 *Spiroptera alata* in the wall of the stomach, several hundred *Holostomum excavatum* and an *Echinostomum revolutum* in the small intestine, 100 *Chaunocephalus ferox* in the large intestine, and 22 *Cathæmasia hians* in the œsophagus, without showing any signs of distress. The other was a two years old horse, in which were found 500 *Ascaris megalocephala*, 200 *Oxyuris curvula*, 200 *Strongylus equinus*, several thousand *Strongylus tetracanthus*, 70 *Anoplocephala perfoliata*, 300 *Filaria papillosa*, and 6 *Cysticercus fistularis*. It is not at all uncommon to find several thousand parasites in one host, and one meets occasional references to the removal of a "bucket-full" of tape-worms or ascarids from an animal which had previously shown no signs of inconvenience. It has been maintained by some that it is only when the general health of the host is impaired by some other cause that intestinal parasites begin to have an injurious influence. This, however, stands in need of confirmation.

If this condition of affairs, then, can exist in domesticated animals which are under constant observation, we need not be surprised to find a similar condition amongst animals in a wild state. The rarity with which the latter appear to actually suffer from or be incapacitated by the inroads of helminth parasites is most striking. I cannot recall more than half-a-dozen instances in over a thousand birds and fishes.

In this connection, however, three points must be borne in mind:—1, It is difficult for us to determine

when an animal is suffering from illness, unless in pronounced cases; 2, The chance of such diseased animals surviving the struggle for existence and being brought to us for examination is small; 3, There is the possibility of immunity enabling the host to withstand the ill-effects liable to be produced by parasites. With regard to the first point, veterinary surgeons are able to detect illness in such animals as horses and cattle with comparative readiness, and yet even they frequently report cases of extensive helminthiasis without apparent symptoms. The second point need hardly be commented upon, for it is only too well known that in nature an animal that is seriously incapacitated very soon drops out.

The tolerance towards extensive helminth infection has more than once been ascribed to immunity, according to which antibodies are elaborated by the host to counteract the effects liable to be produced by any particular parasite. It has been found that many helminths secrete or possess within themselves a specific toxin, capable of producing ill-effects under certain circumstances. The nature of these toxins, however, and the exact manner of their action, are matters on which we have as yet little definite knowledge. It is known, for instance, that *Dibothriocephalus latus* contains three different suhstances, namely, a hæmolysin, a hæmagglutinin and a proteolytic ferment, each of which may produce evil consequences on its host, but under what circumstances exactly is still a matter of doubt. Why only certain cases suffer from the presence of this parasite is difficult to understand. That the illness is not the result of a massive infection, as in ankylostomiasis, seems abundantly proved. The anomaly has been explained on the ground that the toxins are only liberated on the

death of the parasite, and that they produce their ill-effects only so long as the dead parasite is retained within the host. This theory has also been advanced in the case of hepatic fascioliasis, but it lacks confirmation and does not appear to agree with other facts.

A large proportion of such pathological lesions as do occur are due to larval forms. The numerous cestode cysts of mammals, and the cestode and nematode cysts in the body cavity of fishes, may be instanced in vertebrates, while in invertebrates larval cysts of all kinds abound, frequently leading to serious lesions. Here, again, it is wonderful to what an extent helminth infection can go without causing much apparent distress to the host. Forty years ago McIntosh observed that the common green crabs *(Carcinus mœnas)*, at St. Andrew's, were extraordinarily subject to infection with larval trematodes. He found their bodies simply riddled with the minute globular cysts which pervaded every organ and tissue, the liver, gonads, muscles and nerves being especially infected. I have recently confirmed McIntosh's observations, not only at St. Andrew's, but in other parts of the country. This infection is not confined to isolated individuals, but occurs in practically all to a greater or less degree. Occasionally the infection is so enormous that nearly one-half of the crab's anatomy is replaced by trematodes. The edible crab *(Cancer pagurus)* is a victim to the same infection, but to a considerably less extent.

It seems but natural that larval forms should cause more inconvenience to their hosts, for it is to their advantage that the latter should be weakened and thus more readily fall a prey to an animal which will serve as a final host. On the other hand, the adult parasite has

nothing to gain by causing the death of its host. By doing so it terminates its own existence and lessens the chance of dissemination of its offspring.

The study of tropical diseases shows us that, in an uncivilized or semi-civilized state, man is much more subject to infection with helminths than under civilized conditions. The widespread prevalence of such parasites as *Ankylostoma duodenale* and *Schistosomum hæmatobium*, and the relatively small proportion of cases in which serious illness is the result of their presence, are indications that man, under such circumstances, approaches very closely to the condition I have described above as occurring in other animals. It is well known that individuals can get along fairly comfortably although heavily infected with helminth parasites, but it is just as well known that a certain limit is eventually reached, resulting in serious illness or death. It is obvious that parasitic infection is associated with living in a primitive state. Modern civilized cleanliness and sanitary arrangements have altered matters to a considerable extent and have rid man's body of what might be regarded as his natural heritage of parasites. At the same time, however, that they have made him less accustomed to parasitic guests, they have rendered him more intolerant of their evil influence when they do effect an entrance.

The typical life-histories of helminth parasites are so familiar that I need only refer to them in brief. Nematodes, generally speaking, have by far the simplest life-history, and in many cases are almost entirely without metagenesis. The simplest cases are provided by *Oxyuris*, and many ascarids in which the ova extruded from one host are swallowed by another or the same host. In *Oxyuris* the ova immediately they appear in the fæces are

in a condition to reinfect. Some ova require to remain under external conditions a longer time before they are ready to produce adults again. A step further is evidenced by those forms in which the larva is liberated from the ovum, and is only suited for reinfection after it has lived a certain period as such. *Ankylostoma duodenale* appears to be of this class, although its life-history is complicated by the fact that before it can reinfect, it must assume a sort of free encapsuled state, by forming a sheath around itself. In the next type we have the embryo entering some intermediate host and becoming encysted there. This is by far the commonest life-cycle, and is found in a large number of nematodes and most cestodes and trematodes. A more complicated history is shown by some nematodes which pass through a second sexual stage outside the body. The larvæ from this second stage reinfect the host. The remarkable life-histories of the filariæ and *Trichinella spiralis* may be mentioned here. No part of the cycle takes place under external conditions, but the larvæ pass the corresponding stage of their career in the blood. The conditions, however, are to some extent analogous, for blood is an aerobic medium, and according to some observers the presence of oxygen is necessary for the development of larvæ. The complications which are introduced in the case of cestodes are not numerous, and usually consist of a multiplication by budding of the larva within the intermediate host. In the case of trematodes, however, much more elaborate histories may be evolved, and more than one intermediate host may enter into the cycle. There are four larval stages through which a trematode passes, namely, the miracidium, sporocyst, redia and cercaria. The first stage is invariably spent

in water. Each of the other three, however, may be passed through in a different host. The miracidium may enter one host and give rise to the sporocyst. The latter by a process of internal budding produces rediæ, which may be set free and enter a second host. In this it again by a process of budding gives rise to cercariæ, which may in their turn be set free and infect a third host, which is eventually eaten by the final host. All kinds of modification, however, may enter. Thus the sporocyst may take time by the forelock, and produce cercariæ instead of rediæ, and this happens fairly frequently. Again, it may take a step in the other direction, and produce a second brood of sporocysts, and the rediæ also may reproduce rediæ instead of cercariæ. Occasionally, instead of wandering from one host to another, it passes the whole three stages in one host, or two in one host and one in another. Sometimes the process is very much reduced, the sporocyst producing cercariæ which never make their escape until they find themselves in the alimentary canal of their final host. There may be cases in which intermediate hosts are entirely absent, the miracidium simply effecting an entrance into its final host and becoming adult there. This seems to be the case with *Schistosomum*, in which, hitherto, efforts to discover an intermediate host have been unavailing. The intermediate hosts of nematodes, when present, are usually fishes or insects, occasionally crustaceans; cestodes seem to like worms and molluscs as well as fishes, while trematodes show a great preference for molluscs.

The life-histories of most human helminths have been worked out to a more or less satisfactory extent. Owing, however, to the difficulty of discovering intermediate hosts, several remain doubtful. In the case of domesti-

cated animals a considerable amount of work has also been done, with successful results. With regard to the rest of the animal world our knowledge is very meagre. A large number of adult helminths are known, with no corresponding larval stages, and *vice versa*. This to some extent is the result of imperfect description. A further difficulty is that of distinguishing larval forms from one another, possessing as they do so few specific features. For the most part all that can be done in elucidating life-histories is to compare descriptions of adult forms with those of larvæ, and hypothecate their connection if other conditions point to its being a natural or likely one. Feeding experiments are exceedingly difficult to carry out in the case of birds and fishes.

The paths of infection are two, the mouth and the skin, and of these the former is by far the commoner. Depending on the life history of the parasite, introduction by the mouth may take place in water, in food, on dirty fingers, and rarely, if ever, by the air. Introduction through the skin is effected either by the active efforts of the larvæ when the hands or feet are exposed in water or damp places, or possibly through the agency of biting insects.

It is practically an undisputed fact that no helminth parasite is capable of multiplying sexually within the body of its host. It is an essential condition that the ova or larvæ should pass out of the body of the host before they can proceed to grow again. This is generally considered to be due to the fact that the larvæ require ærobic conditions for their development. This may well be the case, but the simplest explanation is found in the well-known developmental doctrine that "ontogeny is an abbreviated recapitulation of phylogeny," or, in other words, that the

life-history and development of an individual tends to be a more or less perfect résumé of its ancestral history.

The introduction of intermediate hosts is a difficulty for which various explanations might be advanced. It is generally agreed that trematodes and cestodes are derived from the Turbellaria, or rather that they have a common ancestry (although SSINITZIN has recently advanced the somewhat extraordinary opinion that the digenetic trematodes have an ancestry in common with the lower crustacea); in the same way the parasitic nematodes are derived from the free-living nematodes. Many of the Turbellaria and free-living nematodes show a tendency towards parasitism, and in fact a large number of the latter are parasitic in the larval stage. It may be considered that prior to the advent of the vertebrates many of the helminths had already become parasitic in invertebrates. With the advance in the evolution of the vertebrates the invertebrates naturally became their chief source of food supply, and it would frequently happen that an invertebrate harbouring a helminth would be ingested by a vertebrate. By some means, which it would be vain to attempt to explain, except possibly by mutation. the helminth became adapted for living in the intestine of the vertebrate. Here it would produce young, which, however, not being trained to parasitism, would find their way back to external media. Growing older, the tendency towards parasitism would again become strong, and they would seek a convenient invertebrate. Thereupon the cycle would be repeated, and we may suppose that the tendency to become adult in invertebrates gradually disappeared, until the present state of affairs was reached, in which the helminth proceeds only a certain distance towards maturity in the invertebrate. Semi-parasitic

nematodes, such as *Gordius* and *Mermis*, show that a somewhat reverse process may have taken place in so far as it was the young of these species which took shelter in invertebrates, and getting older and more able to look after themselves, they returned to a free life. We may suppose that some of these protected larvæ when swallowed with their host by a vertebrate found conditions very much to their liking, and became sexually mature in the new environment. Such problems as these, however, are purely speculative.

In introducing the subject of the specificity of helminths with regard both to host and habitat, I wish it to be distinctly understood that it is not my intention to dogmatize on the matter. I intend simply to lay before you the general principles which to me seem to regulate the distribution of helminths in their various hosts and habitats. It would be vain to endeavour to formulate hard and fast laws, admitting of no exceptions, for such laws are entirely unknown in nature. It must be remembered that nature is in a state of continued flux, and that the phenomena to be observed at any particular instant comprise two components; on the one hand, those which are in a state of relative stability or equilibrium for the time being, and, on the other, those which are in a state of progression or retrogression. It must also be remembered that evolution has not advanced at the same rate in every direction; along some lines it has apparently remained stationary for very lengthy periods. Thus the present biological picture presents organisms on which evolution has acted to a very high degree, and at the same time others, almost archetypic, in which the process has been arrested for many ages. Helminths are in no way exempt from the same conditions, and this must be borne in mind in dealing with the matter in hand.

The idea of specificity is no new one. Even in the beginning of last century we find that helminthologists attached a certain weight to it. This is most evident in the case of DUJARDIN, who treated helminthology more from its bionomic than from its systematic aspect. Later, however, the principle was hardly tenable, for species, apparently similar, were found in all manner of different hosts and habitats. Such species, however, were only superficially similar, and the inability to distinguish them was due entirely to the failure of methods of differentiation. In certain instances there has been a tendency to carry the principle of specificity to an extreme degree, each parasite being regarded as specific for a particular host. This view is quite as unjustifiable as the complete denial of any specificity. My intention here is to show that the degree of specificity is an intermediate one, that no hard and fast rule underlies it, and that it shows the same amount of variation, with the same anomalies and exceptions, as is to be met with in other biological phenomena. It will be shown that the specificity is not so much between one species and another, although that occurs frequently, as between one genus and another, or between two sub-families or two families. Further, the hosts of these species and groups may be isolated species of vertebrates, or genera or groups.

It will be necessary first of all to refer briefly to the classification of the helminths. As in many other branches of biology the taxonomy is in a rather incomplete state. It is only within the last dozen years that anything approaching a natural classification has been attained. The reason for the slow advance is not far to seek. Throughout the animal kingdom the systematic differentiation of one species from another is based to a

large extent upon the study of external characters, such as the number, arrangement and shape of appendages, and this is found to be quite a satisfactory working method in the majority of cases. With the helminths, however, it proved miserably inadequate, nor is that surprising when one considers the structure of a tapeworm or distome. The external features are few and capable of little permutation. The dimensions, shape and colour of the body, the situation and relative sizes of the suckers, the presence of spines, papillæ, or other simple appendages, and the position of the genital aperture sum up all there is to work upon. The absolute insufficiency of these means of diagnosis is apparent when we find that until comparatively recently a large majority of all tapeworms were included in the genus *Tænia*, and the greater half of trematodes in the genus *Distomum*. As a result, twenty years ago the genus *Tænia* comprised nearly 500 species, and the genus *Distomum* well on to 1,000, probably two of the largest genera that have ever existed in zoological nomenclature. The descriptions of older writers are in many cases practically useless, as they could apply equally well to half-a-dozen different species. Attempts were repeatedly made to deal with these cumbrous groups, but as they were all based on external features they were, almost without exception, unsuccessful. It was not until a study of internal structures disclosed their wonderful variety that systematic and natural classification became possible, and we owe the material advances that have since been made, in a large measure, to Prof. Looss of Cairo. The method has led to the differentiation of innumerable allied species, and it would be no exaggeration to say that the number of known species of helminths has been doubled within the last ten years.

The erstwhile genera *Tænia* and *Distomum* have been sub-divided again and again, until they have come to represent taxonomic units of higher rank even than families. These innovations have not materially affected the broad lines of classification, although they have influenced their relative value. The point which I wish to emphasize, however, is that in place of the former apparently homogeneous genera *Tænia* and *Distomum*, we have now a number of distinct groups, each with its respective characteristics, but all more or less intimately and naturally related. It is with these groups and these sub-divisions that I shall deal, for the tænias and the distomes, together with the nematodes, form by far the largest proportion of helminths. It will be impossible in the time at my disposal to deal with each of these three classes, so that I shall content myself for the most part with the treatment of the distomes. The remarkable diversity of their structure and habitat, moreover, makes them most suitable for illustration of the principle I wish to lay before you.

From the point of view of habitat the alimentary canal cannot be regarded as one homogeneous whole, for apart from the mouth, œsophagus and stomach, each of which presents distinct conditions, the intestine shows at least four separate habitats corresponding to the anatomical and physiological divisions. It is well known that *Ankylostoma duodenale* occurs almost invariably in the jejunum, *Ascaris lumbricoides* in the ileum, *Trichuris trichiurus* in the cæcum and *Oxyuris vermicularis* in the rectum. These are four distinct types of nematodes, and it might reasonably be imagined that we had here a high degree of specialization in an extremely highly organized host. That, of course, is true, but the principle is the same

throughout. In birds, for instance, it is not uncommon to find four different species of distomes in the intestine at one time, each maintaining a distinct and circumscribed area. In fishes the same holds good. Cases, however, not uncommonly do occur where there is a certain amount of intermingling of different species, but these are usually closely related species.

Practically every organ and tissue in the body may be the habitat of helminths, but, excluding larval forms, we find the most frequent habitats are the alimentary canal, the liver and gall bladder, the respiratory passages and lungs, or gills in the case of fishes, the urinary system, the vascular system and the subcutaneous tissue. In the case of birds the eyes and the Bursa Fabricii, an appendix of the cloaca, are not uncommon seats of infection; the swim bladder is an additional seat in the case of fishes. Generally speaking, then, the only organs that escape are the brain, the muscles, and the genital system. The brain and muscles are obviously not suitable for the life of adult helminths, but it is curious that the genital passages should escape in the way they seem to do. A few cases are on record of adult helminths being found in the reproductive organs, but they were almost invariably errant forms that had strayed from the intestine. *Oxyuris vermicularis* has even been found in the pouch of Douglas, having wandered there presumably *via* the uterus and Fallopian tubes. An interesting occurrence, of which several records exist, is the inclusion of a trematode, *Prosthogonimus pellucidus* (V. Linstow) within the white of a hen's egg. The explanation is simple. The species lives in the Bursa Fabricii, and occasionally wanders into the rectum and uterus. In the latter it becomes entangled in the albumen before the shell has been formed.

Each habitat is suitable for one or more species of helminth, and it may be taken as a general rule, which however must not be applied with too unrelaxing strictness, that nearly-related species tend to inhabit the same situations in their various hosts. Thus in mammals the *Fasciolidæ*, of which *Fasciola hepatica* is the type, all inhabit the liver and gall bladder, although the genus *Fasciolopsis* is an exception. *Fasciolopsis*, however, appears to live high up in the intestine in close proximity to the bile duct, and may be regarded as a transition stage between an intestinal and a hepatic parasite. *Fascioletta* may come in the same category. The liver-frequenting habit of the *Fasciolidæ* is found not only in terrestrial mammals but in marine mammals as well, for in the porpoise we find the *Brachycladiinæ*, a sub-family of the *Fasciolidæ*, infesting the liver and causing liver-rot, exactly similar to that in sheep. We find representatives of the same sub-family, namely, *Lecithodesmus goliath* (V. Ben), and *Orthosplanchnus arcticus* Odhner, and *O. fraterculus* Odhner in whales and seals. Another group of mammalian hepatic distomes is the *Opisthorcinæ*. This is a sub-family nearly related to but not included under the *Fasciolidæ*. In man we are familiar with *Opisthorcis noverca* Braun, *O. felineus* (Rivolta), *Clonorchis sinensis* (Cobbold), and *C. endemicus* Looss. *O. felineus* occurs in several other carnivorous mammals; *O. tenuicollis* (Rud), a very closely related species in the seals, and *O. lancea* (Dies.) in the dolphin. Some species of *Opisthorcis* are found in the liver of birds, as for instance *O. longissimus* (V. Linst.) in *Ardea stellaris*, *O. simulans* Looss, and *O. geminus* Looss, in several birds. A closely allied genus, *Metorchis*, includes two liver parasites of the cat, *M. albidus* (Brn.), and

M. truncatus (RUD). These also occur in the grey seal *(Halichœrus grypus)*. Here again some representatives of this genus are found in the liver of birds, *e.g.*, *M. crassiusculus* (RUD) in the buzzard *(Buteo buteo)*, and *M. xanthosomus* (CREPL) in the lesser grebe *(Podiceps minor)*. A distantly related sub-family, the *Telorchiinæ*, occurs in the liver, or in one case the duodenum of reptiles. The third great class of liver flukes, properly so called, is the sub-family *Dicrocoeliinæ*, but this is almost exclusively a class of bird-trematodes. The only mammalian representative is *Dicrocoelium dendriticum* (RUD) (= D. lanceatum St. & H.), but this species is quite as widespread as *Fasciola hepatica*. Numerous species of this and the two allied genera *Lyperosomum* and *Athesmia* occur in the liver and gall-bladder of birds. Amphibia are practically free from liver helminths. Fish also rarely harbour adult parasites in the liver or gall-bladder. Amongst the few cases may be mentioned *Fellodistomum fellis* (OLSSON), and *F. agnotum* NICOLL in the cat-fish *(Anarrhichas lupus)*, and *Anisocoelium capitellatum* (RUD), in *Uranoscopus scaber*, but these forms are very different from any of the mammalian liver-flukes. In the *Fellodistominæ*, we have another example of two genera, one of which, *Leioderma*, lives in the intestine close to the opening of the bile duct, and the other is a purely gall-bladder parasite.

Owing to the enormous number of exclusively intestinal helminths it will be impossible to refer even briefly to them in this connection, so that I shall pass on to the other parts of the alimentary canal. Distomes rarely inhabit the stomach or œsophagus in mammals or birds, but in fishes there is a large family, the *Hemiuridæ*, the members of which live almost exclusively in the stomach.

Again in birds the genus *Clinostomum* contains a large number of species, all of which live in the oral cavity; the several species of the genus *Halipegus* exclusively in the mouth of frogs. The cloaca, too, in birds with its appendix the Bursa Fabricii, harbours numerous distomes, which fall into two or three more or less well-defined groups. In the lungs we find another favourite seat of trematodes. In man there is the common *Paragonimus westermanni* (KERBERT), which shows several features of resemblance to *Fasciola hepatica*. It also occurs in several carnivores. In addition there is *Paragonimus rudis* (DIES.) from the otter *(Lutra brasiliensis)* and *Paragonimus compactus* (COBBOLD) from the mongoose *(Mungos fasciatus)*. No distomes have ever been described from the lungs of birds, although a few have occasionally been met with in the trachea. Lung parasites of any kind, in fact, are very uncommon in birds, but I cannot venture to offer any explanation of this rather curious circumstance. In amphibia on the other hand the lungs are a favourite seat for parasites of all kinds, and we find here a special sub-family, the *Haplometrinæ* PRATT, the chief genus of which is *Pneumonœces* LOOSS. The members of this group are found only in the lungs of amphibia and a few reptiles (genus *Macrodera*). In fishes we have an entirely different state of affairs. External gills take the place of internal lungs, and here we find a distinct class of trematodes, which are radically different from the distomes both in structure and in development. Their life history is direct with no intermediate host. They belong to the order *Monogenea*, and are generally referred to as Ectotrematodes. There are numerous genera and species, with much diversity of structure, but as they do not concern us here we shall not discuss them further.

The next viscus we may consider is the bladder and urinary organs. Here, again, we find distinct groups, constantly inhabiting this system and no other. Urinary parasites are comparatively infrequent in mammals and birds, the only common ones being the nematodes, *Eustrongylus gigas* and various species of *Trichosoma*. In reptiles, amphibians and fishes, however, we have a large homogeneous family of trematodes, the *Gorgoderidæ*, which includes the genera *Phyllodistomum* from fishes, *Gorgodera* and *Gorgoderina* from amphibians, and *Plesiochorus* from reptiles. The last illustration which I shall take in this connection is the case of the vascular system. Here we have the well-known *Schistosomum hæmatobium* and *S. japonicum*. These do not belong to the class *Fasciolida*, but represent a small separate class, the *Schistosomida*. A species, the same as, or closely resembling *Schistosomum hæmatobium*, occurs in some of the primates. Other two species, *S. crassum* and *S. indicum*, are found in the ox and sheep. The most closely allied genus is *Bilharziella*, which comprises several species parasitic in birds; and a third recently described genus, *Gigantobilharzia* is also found in birds. These are all the blood trematodes so far as known.

From a consideration of the foregoing, the general application of the principle of specificity of habitat can hardly fail to be clear, and, to my mind, there could be no better demonstration of the validity and correctness of Looss's system of classification. It is an axiomatic biological principle that related species and genera have common habits. Thus, all the carnivores are flesh-eating, wild, fierce animals, lithe of body and swift of foot, and, generally speaking, have habits very much in common. Subdividing them further into *Felidæ*, *Canidæ*

and *Ursidæ*, we find constant differences in habit between the groups, which correspond to their morphological differences. The illustration of this correlation between habit and structure could be carried to the various genera. It is thus not surprising that the same has been found to hold good among the helminths. Moreover, we have several interesting examples of the phylogenetic transmission of acquired habits. Thus amongst the *Fasciolidæ*, the *Brachycladiinæ* may be presumed to have begun to diverge from the parent fasciolid stock at the time when the cetacea first took to an aquatic life, but the hepatic habit remained impressed upon them, so that they continued to be liver parasites.

Turning for a short time to what is, in a sense, the converse of the foregoing, but at the same time an amplification of it: it has been shown that there is a specificity of organic habitat, it will now be shown that there is a specificity of host, always allowing for a certain number of exceptions, as in the first case. This principle is well known to those who have had to work experimentally with helminths. The most familiar case is that of *Ankylostoma duodenale*, which several workers have repeatedly endeavoured to introduce into animals other than man, but with very rare success. Dogs have occasionally been infected, but it has been found impossible to do the same with rabbits, guinea pigs, etc. Again, it is impossible to infect the dog with *Tænia solium*. These, however, are but instances of a very general rule, of which I shall proceed to give a few more comprehensive examples. Of the true liver flukes, the *Fasciolidæ* are strictly confined to mammals, the *Opisthorciinæ* are found equally in mammals and birds, the *Dicrocoeliinæ*, with one exception,

exclusively in birds, and the *Telorchiinæ* entirely in reptiles. No representatives of these are found in any of the lower vertebrates. Subdividing the *Fasciolidæ*, the *Fasciolinæ* are, with a few doubtful exceptions, restricted to the primates, ruminants, and, possibly, marsupials; and the *Brachycladiinæ* to the cetacea and pinnipedes. With the *Fasciolinæ* it is impossible to reduce the specificity to greater detail; but in the *Brachycladiinæ* we have the genus *Brachycladium* confined to the cetacea, *Lecithodesmus* to the whales, and *Orthosplanchnus* to the seals.

The Cyclophyllid or Taenioid cestodes form another group, which is confined, with only three exceptions, to the mammals and birds. In this group sixty-five genera have already been distinguished. One of these is amphibian, another reptilian, and a third has mammalian and reptilian representatives. Of the other sixty-two, forty-two are exclusively confined to birds, and eight to mammals, while twelve are common to both. There is thus evidently a preponderating partiality towards birds.

There are nine families, of which three are exclusively avian. The three largest families are the *Anoplocephalidæ*, the *Davaineidæ*, and the *Hymenolepididæ*. The first is typically mammalian, the other two typically avian. The *Anoplocephalidæ* contain six of the eight exclusive mammalian genera. The four other genera contain a few avian forms. In the *Davaineidæ* only one *(Davainea)* of the six genera contains mammalian forms, and these are isolated cases. In the *Hymenolepididæ* twenty-three genera are exclusively avian, two mammalian, and five contain representatives of both, but, except for *Hymenolepis*, the mammalian forms are few. This differential process could be carried to the individual

species, but it will be hardly necessary to enter into such detail. It will be sufficiently clear, from the facts I have already put forward, that a remarkable degree of specificity does exist, but that there are certain meeting-places where the various genera and species become less specific. This is particularly evident in the case of large and flourishing genera, such as *Hymenolepis*, which, as a type, has apparently become adapted—partly by the nature of its life history, partly by its own physiological requirements—to varying conditions in a large number of different hosts. As a genus, however, it is not very homogeneous, in spite of the remarkable uniformity of its fundamental structure.

A knowledge of the general facts of helminthology is essential to the study of the particular forms which parasitize man, just as much as a general knowledge of Protozoology is essential to the study of malaria and allied diseases. It is evident that the occurrence of helminth parasites in man is only an instance of a general phenomenon in nature. We have seen that no animal is exempt from the attacks of helminths of some description or other, and that the less civilized races of mankind are practically in the same condition. We, in this country, owe our comparative freedom from helminths to the amenities of civilization, but when these fail this exemption disappears. From the point of view of helminthology, then, civilization may be regarded as consisting of three factors, namely: the cooking of food, the wearing of clothes, and the application of sanitation and personal cleanliness. These are the three chief means of defence against helminths. We saw that food was the essential factor in the transmission of parasites in the vast majority of cases. Infection with

trematodes and cestodes (which are heteroxenous) can be acquired only in this way, with the doubtful exception of Schistosomiasis. This, however, applies only to a limited extent in the case of nematodes (which are monoxenous). The most effectual remedies against the inroad of platyhelminths are proper cooking of food and filtration of drinking-water. All parasites are killed by exposure to a temperature of 100° C. (or even less), but it is of importance that the whole of the food be raised to this temperature, not merely the exterior. Most natural waters contain minute crustaceans and other animals, which frequently harbour helminth larvæ. Careful filtering, however, entirely removes those. The wearing of clothes is not of the same far-reaching importance, but it appears to be essential in the case of *Ankylostoma*, *Filaria* and *Schistosomum*. Sanitation and cleanliness are of little less importance than the proper cooking of food. They are specially important from an epidemiological point of view. The only means of dealing with an epidemic consists in the immediate destruction or disposal of the fæces from the infected cases, and in scrupulous personal cleanliness amongst those exposed to infection. Were these measures strictly carried out, there would be no such outbreaks of ankylostomiasis as have been notorious in Europe of recent years. It is this third factor which is most largely concerned in the spread of nematodes. There remains a fourth factor, which is not so directly connected with, or dependent on, civilization, namely, the transmission of helminths through the active agency of insects. The outstanding instance, of course, is filariasis. This is independent of food, sanitation, and clothing—unless, indeed, the whole body, including the face, could be covered. Even here,

however, a means has been found to limit the occurrence of the disease, namely, by filling up the swamps and marshes, and thus destroying the breeding grounds of the mosquito. This measure might well enough be included under sanitation. These, then, are the main prophylactic and preventive measures, and, could they be efficiently carried out in all cases, man would cease to be afflicted with helminth parasites. This, certainly, is a counsel of perfection, and it seems vain to hope for its ultimate attainment in tropical countries. So long, however, as it fails of complete realization, just as long will their be helminthiasis in these regions. Medicinal remedies in places where helminthiasis is endemic are of merely transient utility. They only touch the outcrop in various isolated individuals, all the while the root of the evil remains untouched. Here, assuredly, one effort directed towards prophylaxis is worth a hundred towards cure.

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